Dead and Downed Fuel Load

This document describes methods for monitoring changes in dead and downed fuel load in forest areas using permanently marked planar transects of adjustable length. To calculate fuel load, woody fuel is tallied by size class (diameters of <0.25", 0.25"-1.0", 1.0-3.0", >3.0") and litter and duff depth is measured. This protocol was developed for the National Park Service's (NPS) fire monitoring program but may be adapted for other monitoring purposes. For background information on the fire monitoring program, including the purpose and overview of the program, related policy, and personnel responsibilities, refer to Chapter 1, pages 1-5 of the NPS Fire Monitoring Handbook (FMH, http://www.nps.gov/fire/fmh/FEMHandbook.pdf). An overview of management objectives and the process for developing corresponding monitoring program objectives is reviewed in Chapter 3, pages 19-32 of the FMH.

Sampling design, including defining the population of interest, pilot sampling, calculating minimum sample size, and addressing potential design problems, is described in FMH Chapter 4, pages 33-54. Methods for generating and selecting plot locations and installing plots are found in FMH Chapter 5, pages 59-79. The schedule for monitoring prior to and following fire treatment is located in FMH Chapter 5, pages 55-58, although the schedule may be revised for other purposes. For a list of field equipment needs recommended for implementing this protocol, see FMH Appendix E, pages 221-224. Information about monitoring program file maintenance and data storage is found in FMH Chapter 5, pages 112-113. To review data quality procedures, see FMH Chapter 5, pages 114-117.

The field methods for the protocol described below are taken from FMH Chapter 5, pages 103-105 (http://www.nps.gov/fire/fmh/FEMHandbook.pdf). Specific forms developed for field data collection follow the protocol description.

Monitoring Dead & Downed Fuel Load

On all forest monitoring plots, measure dead and detached woody fuel as well as duff and litter depths. These measurements are taken along fuel inventory transects, which must be relocatable to allow evaluation of postburn fuel load. Transects extend in random directions originating from the centerline at 10, 20, 30, and 40 m (Figure 32).

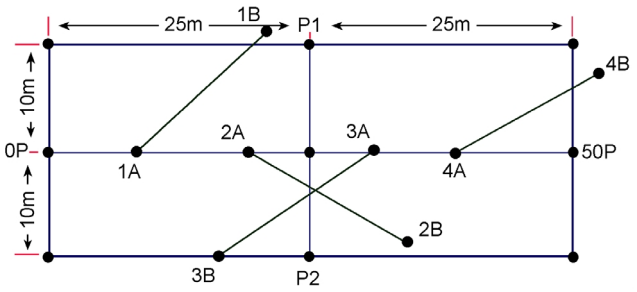

Figure 32. Location of fuel inventory transects.

Unlike herbaceous transects, fuel load transects can cross each other (Brown 1996). In many monitoring types the transect length is 50 ft, but in types with sparser fuels it may exceed that (see page 45). Check your protocols (FMH-4) before proceeding.

Fuel Load Measurements

Fuel load measurements and the transects used to sample them traditionally use English measurements, **not** metric.

Lay out the appropriate length tape along the transect in a random direction (Appendix B). Place a labeled tag at each end of the transect (see page 70 for a description of how to label tags). Measure the percent slope of the transect (from end to end) in percent.

When an Obstruction is Encountered Along the Fuel Transect

If the fuel transect azimuth goes directly through a rock or stump, in most cases you can run the tape up and over it. If the obstruction is a tree, go around it and pick up the correct azimuth on the other side. Be sure to note on the FMH-19 on which side of the bole the tape deviated so that it will be strung the same way in the future.

Fuel Load Accuracy Standards

Accuracy standards for each variable discussed in this section are listed at the end of this section (Table 27, page 105).

RS PROCEDURES

Working along the distances defined in the monitoring type protocols (FMH-4), tally each particle intersected along a preselected side of the tape, categorized by size class. A go-no-go gauge with openings (0.25, 1, and 3 in) works well for separating borderline particles into size classes and for training the eye to recognize these size classes (Figure 33). Measurement of all particles is taken perpendicular to the point where the tape crosses the central axis (Figure 34, page 104). Count intercepts along the transect plane up to 6 ft from the ground. Count dead and down woody material, but not cones, bark, needles and leaves. Do not count stems and branches attached to standing shrubs or trees (Brown 1974; Brown and others 1982). For additional details on tallying downed woody material, refer to the notes on the reverse side of FMH-19.

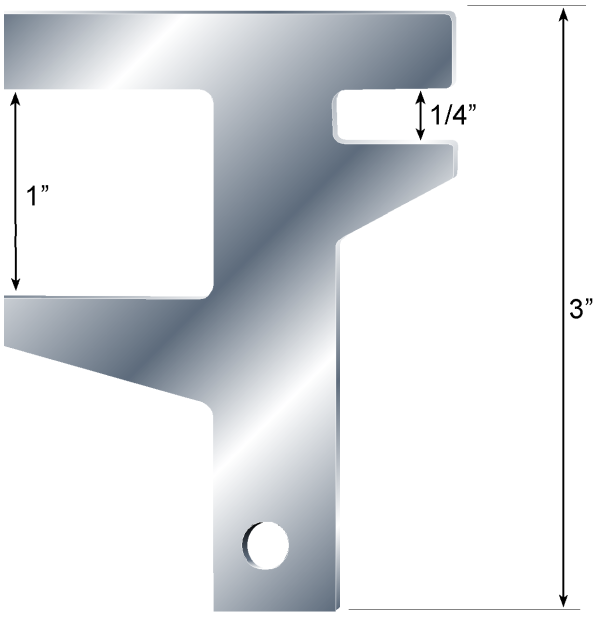

Figure 33. Graphic of a go-no-go gauge.

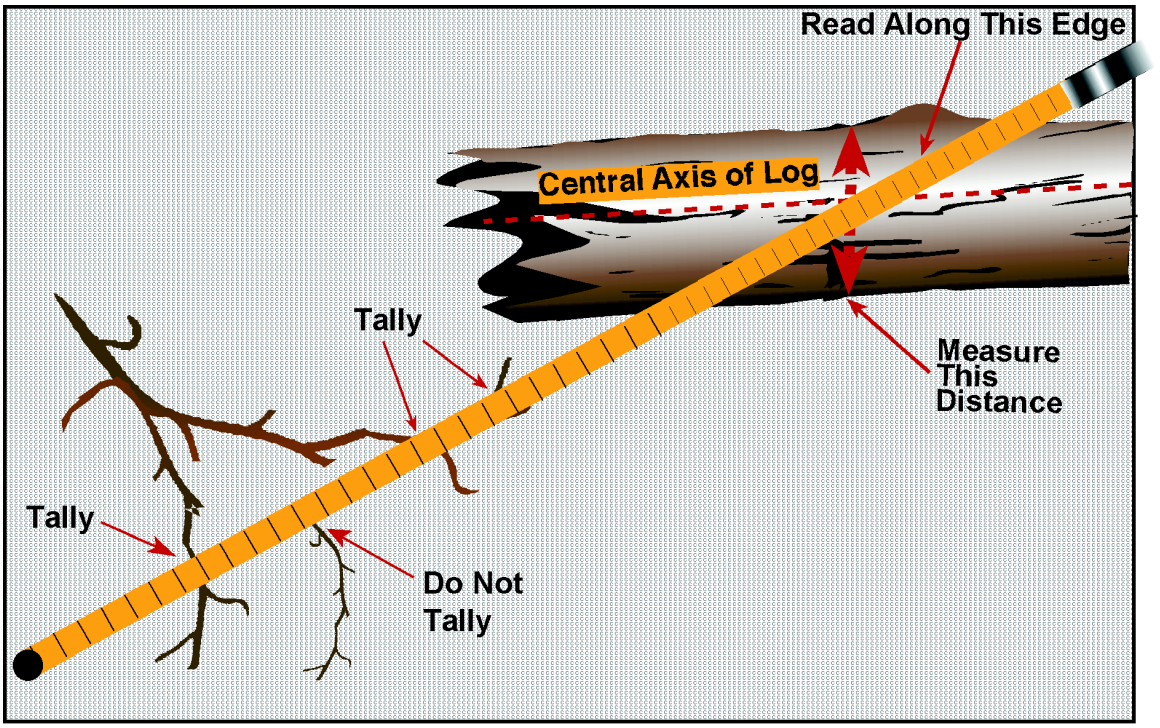

Figure 34. Tally rules for dead and down fuel.
Count all intersections, even curved pieces. All intersections must include the central axis in order to be tallied.

Table 26. Suggested lengths of transect lines to tally fuels by size class.

Size Class	Suggested Length
0–0.25" (0–0.62 cm) diameter (1 hour)	tally from 0–6 ft
0.25–1" (0.62–2.54 cm) diameter (10 hour)	tally from 0–6 ft
1–3" (2.54–7.62 cm) diameter (100 hour)	tally from 0–12 ft
>3" (>7.62 cm) diameter (1,000 hour)	measure each log from 0–50 ft

Differentiate between 3 in (or larger) diameter particles that are sound and those that are rotten. Rotten wood is that which is obviously deteriorating or punky. Measure the particle diameter to the nearest 0.5 in with a diameter tape or ruler. Ignore particles buried more than halfway into the duff at the point of intersection. Visually reconstruct rotten logs as a cylinder and estimate the diameter. This reconstructed diameter should reflect the existing wood mass, not the original sound diameter.

Take depth measurements for litter and duff (as defined in the Glossary) at 10 points along each fuel transect—that is at 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 ft. If the transect is longer than 50 ft, do not take additional litter and duff measurements. Do not take measurements at the stake (0 point); it is an unnatural structure that traps materials. At each sampling point, gently insert a trowel or knife into the ground until you hit mineral soil, then carefully pull it away exposing the litter/duff profile. Locate the boundary between the litter and duff layers. Vertically measure the litter and duff to the nearest tenth of an inch. Refill holes created by this monitoring technique. Do not include twigs and larger stems in litter depth measurements.

You may choose to install duff pins to measure duff reduction instead of digging and measuring the depth of holes. Duff pins, however, are easy to trip over or pull out, and therefore should be used only where traffic (human or other animal) is limited.

Record the above dead and downed fuel data on the Forest plot fuels inventory data sheet (FMH-19, in Appendix A).

Measuring Duff and Litter

You can dig and measure in one step if you engrave or etch a ruler in tenths of inches on the back of your trowel. Use paint or nail polish to mark the major gradations.

DEAL WITH SAMPLING PROBLEMS

Occasionally moss, a tree trunk, stump, log, or large rock will occur at a litter or duff depth data collection point. If moss is present, measure the duff from the base of the green portion of the moss. If a tree, stump or large rock is on the point, record the litter or duff depth as zero, even if there is litter or duff on top of the stump or rock. If a log is in the middle of the litter or duff measuring point, move the data collection point 1 ft over to the right, perpendicular to the sampling plane.

Table 27. Accuracy standards for fuel (RS) variables.

Fuel Load	
% Slope	± 5%
Diameter of ≥3" logs	± 0.5 in (1.2 cm)
Litter or Duff Depth	± 0.5 in (1.2 cm)

Park/Unit 4-Character Alpha Code: _____

FMH-19 **FOREST PLOT FUELS INVENTORY DATA SHEET** Page __ of __

Plot ID: _____ B / C (Circle One) Date: ____/____/____

Burn Unit: _____ Recorders: _____

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Transect lengths, in feet: 0-0.25: _____ 0.25-1: _____ 1-3: _____ 3+s: _____ 3+r: _____

	# of intercepts			Diameter (in)		Litter and Duff Depths (in)					
	0–.25" (1-hr)	.25–1" (10-hr)	1–3" (100-hr)	3+s (1,000-hr)	3+r		L	D		L	D
Transect 1						1			25		
Compass Dir._____°						5			30		
Slope___%						10			35		
Tag 1A & 1B						15			40		
						20			45		
Transect 2						1			25		
Compass Dir._____°						5			30		
Slope___%						10			35		
Tag 2A & 2B						15			40		
						20			45		
Transect 3						1			25		
Compass Dir._____°						5			30		
Slope___%						10			35		
Tag 3A & 3B						15			40		
						20			45		
Transect 4						1			25		
Compass Dir._____°						5			30		
Slope___%						10			35		
Tag 4A & 4B						15			40		
						20			45		

Note: See reverse for definitions and tally rules

Date Entered: ____/____/____ FMH-19

Definitions

Litter—Includes freshly fallen leaves, needles, bark, flakes, fruits (e.g., acorns, cones), cone scales, dead matted grass, and a variety of miscellaneous vegetative parts. Does not include twigs and larger stems.

Duff—The fermentation and humus layers; does not include the freshly cast material in the litter layer. The top of the duff is where needles, leaves, fruits and other castoff vegetative material have noticeably begun to decompose. Individual particles usually are bound by fungal mycelia. The bottom of the duff is mineral soil.

Downed Woody Material—Dead twigs, branches, stems and boles of trees and shrubs that have fallen and lie on or above the ground.

Obstructions Encountered Along Fuel Transects—If the fuel transect azimuth goes directly through a rock or stump, in most cases you can run the tape up and over it. If the obstruction is a tree, go around it and pick up the correct azimuth on the other side. Be sure to note on the FMH-19 on which side of the bole the tape deviated so that it will be strung the same way in the future.

Litter and Duff Measurement Rules

- If the transect is longer than 50 ft, do not take additional litter and duff measurements.
- Do not take measurements at the stake (0 point); it is an unnatural structure that traps materials.
- At each sampling point, gently insert a trowel or knife into the ground, until you hit mineral soil, then carefully pull it away exposing the litter/duff profile. Locate the boundary between the litter and duff layers. Vertically measure the litter and duff to the nearest tenth of an inch.
- Refill holes created by this monitoring technique.
- Do not include twigs and larger stems in litter depth measurements.
- Occasionally moss, a tree trunk, stump, log, or large rock will occur at a litter or duff depth data collection point. If moss is present, measure the duff from the base of the green portion of the moss. If a tree, stump or large rock is on the point, record the litter or duff depth as zero, even if there is litter or duff on top of the stump or rock.
- If a log is in the middle of the litter or duff measuring point, move the data collection point one foot over to the right, perpendicular to the sampling plane.

Tally Rules for Downed Woody Material

- Measure woody material first to avoid disturbing it and biasing your estimates.
- Do not count dead woody stems and branches still attached to standing shrubs and trees.
- Do not count twigs and branches when the intersection between the central axis of the particle and the sampling plane lies in the duff.
- If the sampling plane intersects the end of a piece, tally only if the central axis is crossed.
- Do not tally any particle having a central axis that coincides perfectly with the sampling plane.
- If the sampling plane intersects a curved piece more than once, tally each intersection.
- Tally uprooted stumps and roots not encased in dirt. Do not tally undisturbed stumps.
- For rotten logs that have fallen apart, visually construct a cylinder containing the rotten material and estimate its diameter.
- When stumps, logs, and trees occur at the point of measurement, offset 1 ft (0.3 m) perpendicular to the right side of the sampling plane.
- Measure through rotten logs whose central axis is in the duff layer.

Park/Unit 4-Character Alpha Code: _____

FMH-4 **MONITORING TYPE DESCRIPTION SHEET**

Monitoring Type Code: _____ Date Described: __/__/__

Monitoring Type Name: _____

FGDC Association(s): _____

Preparer(s) (FEMO/RMS/FMO): _____

Burn Prescription (including other treatments: _____

Management Objective(s): _____

Monitoring Objective(s):_____

Objective Variable(s): _____

Physical Description: _____

Biological Description:_____

Rejection Criteria:_____

Notes:_____

Date Entered: ____/____/____

PLOT PROTOCOLS

GENERAL PROTOCOLS		(Circle One)			(Circle One)	
Preburn	Control Treatment Plots (Opt)	Y	N	Herb Height (Opt)	Y	N
	Herbaceous Density (Opt)	Y	N	Abbreviated Tags (Opt)	Y	N
	OP/Origin Buried (Opt)	Y	N	Herb. Fuel Load (Opt)	Y	N
	Voucher Specimens (Opt)	Y	N	Brush Fuel Load (Opt)	Y	N
	Count Dead Branches of Living Plants as Dead (Opt)				Y	N
	Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s):					
	Length/Width Sample Area for Shrubs:			Stakes Installed:		
	Herbaceous Frame Dimensions:					
	Herbaceous Density Data Collected At:					
Burn	Duff Moisture (Opt)	Y	N	Flame Depth (Opt)	Y	N
Postburn	100 Pt. Burn Severity (Opt)	Y	N	Herb. Fuel Load (Opt)	Y	N
	Herbaceous/Shrub Data (Opt): FMH- 15/16/17/18					

FOREST PLOT PROTOCOLS		(Circle One)			(Circle One)	
Overstory (>15 cm)	Live Tree Damage (Opt)	Y	N	Live Crown Position (Opt)	Y	N
	Dead Tree Damage (Opt)	Y	N	Dead Crown Position (Opt)	Y	N
	Record DBH Year-1 (Opt)	Y	N			
	Length/Width of Sample Area:			Quarters Sampled: Subset • Q1 • Q2 • Q3 • Q4		
Pole-size (≥2.5≤15)	Height (Opt)	Y	N	Poles Tagged (Opt)	Y	N
	Record DBH Year-1 (Opt)	Y	N	Dead Pole Height (Opt)	Y	N
	Length/Width of Sample Area:			Quarters Sampled: Subset • Q1 • Q2 • Q3 • Q4		
Seedling (<2.5 cm)	Height (Opt)	Y	N	Seedlings Mapped (Opt)	Y	N
	Dead Seedlings (Opt)	Y	N	Dead Seedling Height (Opt)	Y	N
	Length/Width of Sample Area:			Quarters Sampled: Subset • Q1 • Q2 • Q3 • Q4		
Fuel Load	Sampling Plane Lengths:___ 1 hr • ___ 10 hr • ___ 100 hr • ___ 1,000 hr-s • ___ 1,000 hr-r					
Herbaceous	Cover Data Collected at: Q4–Q1 • Q3–Q2 • 0P–50P • Q4–30 m					
Postburn	Char Height (Opt)	Y	N	Poles in Assessment (Opt)	Y	N
	Collect Severity Along: Fuel Transects • Herbaceous Transects					

(Opt) = Optional

Park/Unit 4-Character Alpha Code: _____

FMH-5 **PLOT LOCATION DATA SHEET**

Plot ID: _____ B / C (Circle One) Date: ___/___/___

Burn Unit: _____ Recorder(s): _____

Topo Quad: _____ Transect Azimuth: ____ Declination: _____

UTM ZONE: _____	Lat: _____	Section: _____	Slope (%) along Transect Azimuth: _____
UTMN: _____	Long: _____	Township: _____	Slope (%) of Hillside: _____
UTME: _____		Range: _____	Aspect: _____ Elevation: _____

Location Information Determined by (Circle One): Map & Compass / GPS

If determined by GPS: Datum used: _____ (Circle One) PDOP/EHE: _____

Fire History of the Plot (including the date of the last known fire):_____

_____

1. Road and trail used to travel to the plot:_____

_____

_____

2. True compass bearing at point where road/trail is left to hike to plot: _____°

3. Describe the route to the plot; include or attach a hand-drawn map illustrating these directions, including the plot layout, plot reference stake and other significant features. In addition, attach a topo, orthophoto, and/or trail map.

4. Describe reference feature: _____

5. True compass bearing from plot reference feature to plot reference stake: _____°

6. Distance from reference feature to reference stake: _____m

7. Problems, comments, notes:_____

_____

_____

FMH-5A **HISTORY OF SITE VISITS**

Plot ID: ________________ B / C (Circle One) Burn Unit: ________________________

Date	Burn Status	Purpose	Comments

 Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: _____

FMH-6 **SPECIES CODE LIST** Page ___ of ___

Use this form to record unknowns and official species codes. **Tip:** Place an asterisk next to each species you voucher.

Species Code	Life Form	Genus/Species (spell out full name)	Native (Circle One)	Annual/ Biennial/ Perennial
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
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			Y N	
			Y N	
			Y N	
			Y N	
			Y N	
			Y N	

Life Forms Codes:

A	Fern or Fern Ally	**G**	Grass	**R**	Grass-like	**T**	Tree	*****	Substrate
F	Forb	**N**	Non-vascular	**S**	Shrub	**U**	Subshrub	**V**	Vine

Date Entered: ___/___/___

VOUCHER SPECIMEN DATA COLLECTION FORMS

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

Park/Unit 4-Character Alpha Code: _____

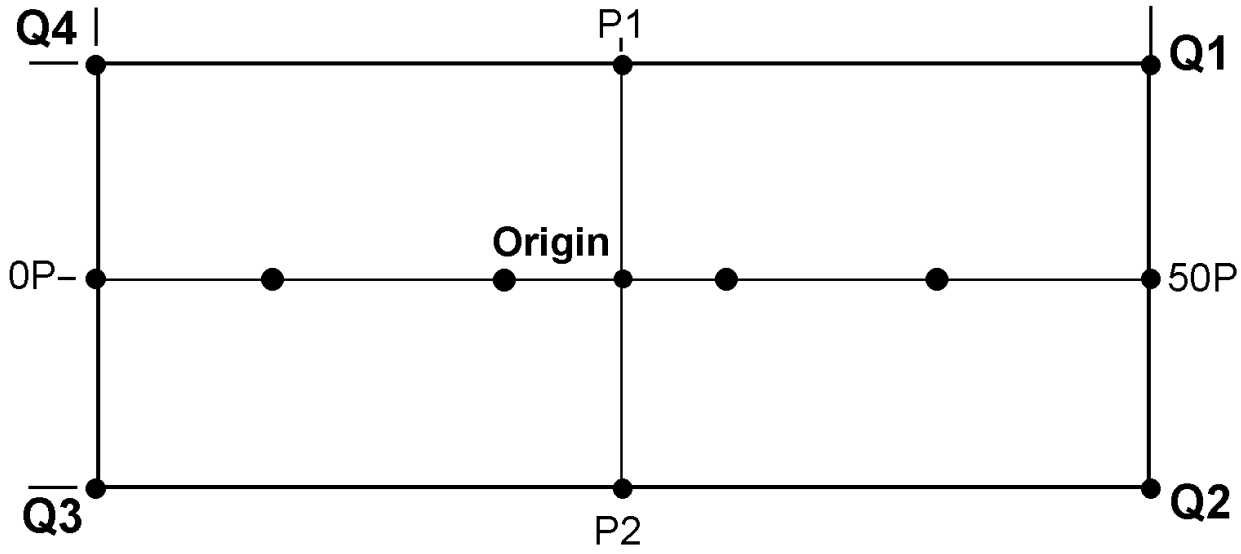
FMH-7 **FOREST PLOT DATA SHEET**

Plot ID: _____ B / C (Circle One) Date: ____/____/____

Burn Unit: _____ Recorders: _____

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr___; ____-mo___



Overstory: _____m^2 in Q ____ Pole: _____m^2 in Q _____ Seedling: _____m^2 in Q ____

Sampling Areas: Shrub: _____m^2 along Q4–Q1 • Q3–Q2 • 0P–50P • Q4–30 m

Shade in the sampling areas for each tree class and for the shrub sampling area(s) on the plot layout above.

Photo Subject Order		**Fuel Load Transects**		
			Azimuth	Slope
1. 0P → Origin	6. Q2 → Q3			
2. Q4 → Q1	7. P2 → Origin	1		
3. P1 → Origin	8. Q3 → Q2	2		
4. Q1 → Q4	9. Origin → REF	3		
5. 50P → Origin	10. REF → Origin	4		

Record photo documentation data for each visit on FMH-23, Photographic record sheet

Draw in fuel load transect lines on the plot layout above.

Date Entered: ____/____/____